Optics for Recycler Stochastic Cooling

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The optics for the Recycler stochastic cooling system have been measured. Via a series of beam expanders and telescopes, the object is to transmit a 1310 nanometer laser beam across a cord of the Recycler that is 1850 feet in length. By cutting across the ring, the feedback signal can be timed to precisely kick the beam with several picosecond accuracy. Three such transmission links will be commissioned. The transmitters are Ortel 10-12 GHz units. Each produces from 2-7 milliwatts of infrared light. The systems are similar to those used in the Antiproton source.[1]

A series of experiments were performed to find the best focal positions to produce a spot size under three inches in diameter on the receiving end of the light link. This was done empirically in the Recycler peanut enclosures. The optimal distance between the New Focus grin lens and the beam expanding telescope was found to be 4.875 inches. See figure 1 for details. The telescopes on the transmission side are Special Optics Model 50-51-20X-1310 twenty time beam expanders with a 51 mm diameter. Each of these units has a unique focusing range; hence, they needed to be measured individually. The details of focusing positions are listed in table 1 for each serial number.

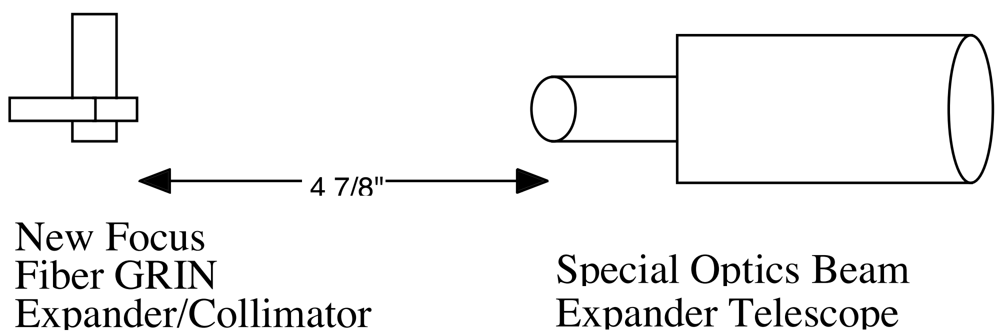

Figure 1. Position of fiber expander with respect to telescope expander for Red Focal length

Transmitter Telescope Settings Special Optics Model 50-51-20X-1310

Positions are in "turns" from clockwise stop @ dial indicator setting

Serial Number	Red focus	1310 focus
7092A-1	0.5 @ 0.1	3.65 @ 2.5
7092A-4	1.1 @ 0.8	4.3 @ 0
5398A-1	0.3 @ 9.5	3.5 @ 1.5
6587A-2	2.96 @ 0.4	6.16 @ 2.4

Table 1. Settings for 51 mm transmission telescopes

In order to facilitate the initial aiming of the beam, a red laser diode is utilized for visual ease. An extra 4 inch view port was added on the transmitter end of the light pipe to allow initial visual access for a Meade 4 inch telescope. The lasers, both infrared and red diode, are single mode fiber based and connected via an optical FC type bullet. This allows switching wavelengths without touching the optical hardware.

Another visual aid is the infrared video camera that is located on the receiving end. The camera is an Electro Physics model 7290AX that has a response from infrared through visible light. The inside of the flange on the receiving end was sprayed with twenty light coats of a high reflectivity coating from Munsell Color. The composition of the coating is barium sulfate with a reflectivity in excess of 90% for wavelengths between 200-2500 nanometers. A "rear view mirror" was installed in the vacuum pipe to allow viewing the inside of the receiving end flange. The camera is mounted on the receiver light table along with the receiving telescopes. Closed circuit television channel 20 on the main injector link allows remote viewing of the laser beams (striking the end flange) with good resolution. An added feature is the remote control of a light fixture on the receiving light table. This added light aids in seeing the view ports from the MI 21 transmission end. It is important to turn the light off when viewing the laser beams to avoid saturating the video camera.

All vacuum view ports (with the exception of the 4 inch unit on the transmitter side from MDC) are quartz with anti-reflection coating for 1310 nanometers. The four inch units are Larsen Electronic Glass model VQZ-400-L16 with NW160 flange, the 1.5 inch units are model VQZ-150-F4 with 4.5 inch conflat flange.

Due to the difference in wavelength, the focal length of the telescope expander must be varied. On all units tested, the difference between red and 1310 nanometer focus is 3.2 full turns out from the red position. All telescopes are mounted on tilt rotation tables (Newport model PO80N, +/- 7 degrees tilt, +/- 8.5 degrees rotation) that allow for accurate positioning. A combination of direct visual inspection and viewing via the Meade telescope are required to get the visible laser beam pointed to the receiving flange. The final focus and position of the beam is then adjusted to achieve a spot size smaller than three inches in diameter. These fine tune adjustments are done by viewing the televised signal. At this point, the infrared laser is connected. The light source on the receiving end is turned off and further adjustments are made to obtain the desired beam spot size.

The receiving end utilizes a 71 mm beam expanding telescope, Special Optics model 52-71-20X-1310. The optimum distance for placing the Hamamatsu photo diode from the telescope is 2.25 inches, see figure 2. Table 2 contains the measured settings for the receiving telescopes.

The optical hardware is temperature sensitive. Extensive data logging of the optical links for the proton cooling experiment directly shows a correlation of beam pointing stability to temperature. To overcome this effect, both light tables are enclosed in a Plexiglas housing. While the peanuts are controlled to a couple of degrees

Fahrenheit, the Plexiglas enclosures will be regulated to better than half a degree Fahrenheit by use of a temperature feedback controller.

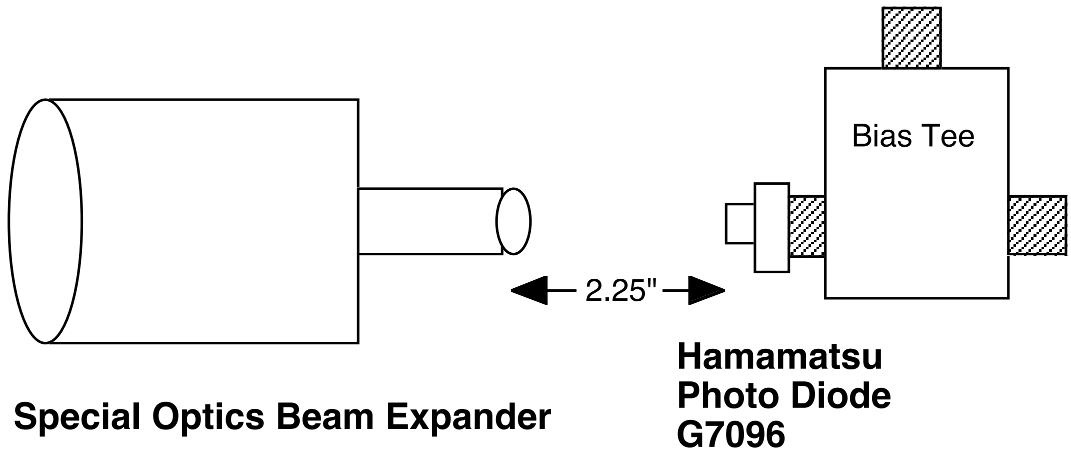

Figure 2. Receiver telescope focal positions

Receiver Telescope Settings Special Optics Model 52-71-20X-1310

Positions are in "turns" from clockwise stop @ dial indicator setting

Serial Number	1310 focus
5398C-2	9 @ 3
5398C-1	9.6 @ 7
7092B-1	10 @ 0
7092B-2	10 @ 0

Table 2. Settings for 71 mm transmission telescopes

References:

1. Wide Band Free Space Transmission Link Utilizing a Modulated Infrared Laser, Ralph Pasquinelli, IEEE proceedings of the 1999 Particle Accelerator Conference, Paper TUA12 New York, New York